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THE USE OF VLSI TECHNOLOGY FOR THE REAL-TIME GENERATION OF GRAPHICS DISPLAYS: A PROPOSAL

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This study proposes to look at special purpose VLSI architectures for real-time display generation. The goal is the development of a methodology for taking a selected computer graphics algorithm and producing a silicon system that performs that algorithm. Several graphics algorithms that have the potential for VLSI implementation will be identified and studied. Part of this effort will be a characterization of the changes in the architecture of the graphics display system made necessary by the addition of such real-time display generation.

The Use of VLSI Technology for the Real-Time Generation of Graphics Displays: A Proposal ‡

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ABSTRACT

This study proposes to look at special purpose VLSI architectures for real-time display generation. The goal is the development of a methodology for taking a selected computer graphics algorithm and producing a silicon system that performs that algorithm. Several graphics algorithms that have the potential for VLSI implementation will be identified and studied. Part of this effort will be a characterization of the changes in the architecture of the graphics display system made necessary by the addition of such real-time display generators.

Categories and Subject Descriptors: I.3.1 [**Hardware Architecture**]: architectures, parallel processing, VLSI implementations; I.3.2 [**Graphics Systems**]: multiprocessing systems; I.3.3 [**Picture/Image Generation**]: surface visualization; I.3.5 [**Computational Geometry and Object Modeling**]: data structures, discrete planar contours, surface approximation, surface generation, surface representation, surfaces, 3D graphics; I.3.6 [**Methodology and Techniques**]: contouring, interactive systems, parallel processing; I.3.7 [**Three-Dimensional Graphics and Realism**]: line drawings, line generation algorithms, real-time graphics, surface plotting, surface visualization, surfaces; I.3.m [**Miscellaneous**]: VLSI;

General Terms: Algorithms, architecture;

Additional Key Words and Phrases: contour surface display generation, real-time display generation;

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1. Background

Highly reactive displays for weapons systems, and highly interactive simulators are an obvious need of the Department of Defense. Both of these areas rely on the capabilities of graphics systems for the real-time generation and display of computer images. The idea behind real-time, interactive systems is to provide the human user of such a system immediate feedback of visual information in response to any physical control manipulations made. Such capabilities are necessary in visual training simulators, command/control situations, and other time-critical applications. The cost-effectiveness of flight training simulators is well-known [Collier,1983], [Orlansky,1983], [Needham,1983], and [Schachter,1983]. Historically, the effort to improve the capabilities for such systems has been a push-and-pull cycle of improved algorithms driving special hardware additions to the graphics system. This cycle has been seen several times in the development of the graphics system.

The first cycle of hardware improvements to the graphics system was the development of matrix multipliers for the real-time matrix operations necessary for rotating, scaling, and translating vectors. This had a direct effect on the architectures of display devices in that such special purpose hardware was quickly added to the commercially produced graphics systems. This addition to the display system was quite important in that it allowed the development of real-time interactive applications not previously possible without the special hardware. (One example of this has been the abandonment in the field of chemistry of the use of hard models of large molecules for the more readily manipulated computer models).

The second cycle of improvements has been the offloading of the graphics and interaction functionalities from the host computer to a special processor dedicated to the graphics system. The goal behind this was again performance improvement. The real-time operations desired by the interactive graphics user community had risen to such a level of sophistication that the traditional time-sharing host for the graphics system could no longer provide sufficient response.

The third cycle of hardware improvements to the graphics system is currently beginning. This cycle is driven both by the continuing need for performance improvements in the

computation of graphics algorithms, and by the emerging capabilities of the VLSI chip. VLSI technology provides the capability for the parallel operation of large numbers of relatively inexpensive processors [Mead,1980] and [Sutherland,1977]. This technology has proven to be very seductive to the graphics community in that research has begun at several institutions on broadening the scope of the real-time operation capability of the graphics system [Clark,1981], [Clark,1982], [Hoffman,1983], [Roman,1981], [Sproull,1981], [Weinberg,1983], [Zyda,1981], [Zyda,1982], [Zyda,1983], [Zyda,1984a], [Zyda,1984b], and [Zyda,1984c].

2. Proposed Program of This Research

The research proposed in this study is part of the third cycle. It concerns the design of special purpose VLSI architectures for real-time display generation. The thrust of this research is the development of a methodology for taking a selected computer graphics algorithm and producing a silicon chip and system that performs that algorithm. This work can be thought of as a VHSIC insertion project. The scope of this work is quite large in comparison to the other cycles of special graphics hardware development. It encompasses the areas of real-time graphics software engineering, and VLSI computer architectures. Real-time graphics software engineering is part of this effort in that before one commits to implementing a particular graphics algorithm in silicon, one needs to be able to evaluate whether or not that algorithm can be computed in real-time on a currently available, high-performance graphics system. The research effort in this part of the project is to produce a system that can automatically model the desired algorithm such that runtime parameters can be obtained for hypothetical architectures.

VLSI computer architectures are part of this effort in that the hypothetical architectures which we are modeling are those capable of being implemented in VLSI. The research effort in this part of the project is twofold. The first part is the determination and evaluation of a special architecture for the studied algorithm. The determination of the architecture is accomplished through iterative design refinement driven by previous experience with such special processors. The evaluation of the architecture is both a runtime evaluation, and a technological evaluation. The runtime evaluation determines if the studied algorithm is capable of being executed in real-

time on the hypothetical architecture. The technological evaluation determines if the proposed architecture is capable of being built within current technological constraints. Part of this effort is the examination of the changes required in the design of the graphics system that receives the output of the real-time display generator.

The second part of the proposed research in the area of VLSI computer architectures is the evaluation and refinement of the software tools available for putting an architecture on silicon. Since VLSI technology is relatively new, the available software tools for producing special purpose VLSI chips are crude. The research plan outlined to this point presupposes the existence of such software. Consequently, the proposed research necessarily encompasses the refinement and development of such software tools.

3. Specific Work Objectives

The first objective of this study is to examine the proposed architecture of one real-time display generator, the contour surface display generator of [Zyda,1984a], [Zyda,1984b], and [Zyda,1984c]. This requires a detailed study of both the architecture of the contour surface display generator, and its intended application. Part of this study will be the development of a modeling methodology for evaluating the physical parameters inherent to both the application, and the architecture.

The second objective of this study is an examination of the input and output parameters obtained from the system model in order to determine exactly how that display generator can be interfaced to a graphics system. This study will be made with respect to relevant commercially available graphics systems in that the current functionality of those systems will be maintained. The result of this study will be a characterization of the changes necessary in the design of current graphics display systems in order to allow the addition of the contour surface display generator.

The third objective of this study is the identification of other graphics algorithms that have the potential for implementation in VLSI. Since the full evaluation of the identified algorithms is

a substantial research project, this study will only be a cursory examination of those algorithms for their distributability among multiple processors. Part of this study will attempt to determine if the changes proposed for the graphics system for the contour surface display generator are applicable to other real-time display generators.

The fourth objective of this study is to acquire and examine the available hardware and software technology necessary for the actual construction of the contour surface display generator. The beginning of this step will be the refinement of the architecture proposed from the results of objectives one and two for the contour surface display generator.

The final objective proposed for this study will be an evaluation of the steps performed in the design of the contour surface display generator, with the goal of establishing a methodology for facilitating the implementation of other graphics algorithms in VLSI. Part of this methodology will be a recommendation as to the design changes necessary in the graphics system for support of such real-time display generators.

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